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Communications Through Plasma Sheaths: Alternative Approaches Using Nonlinear Properties  
of the Plasma  
AFOSR F49620-93-1-0058

Final Report  
7/31/97

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#### OBJECTIVE

We developed useful results in connection with the use of nonlinear plasma properties to enhance communication properties and improve drag reduction and flight characteristics of hypersonic vehicles.

Over the past three years, we carried out a detailed investigation of the relevant plasma processes, such as Raman and Brillouin scattering, ion-acoustic pulses and fast electrons. The objective of this work was to find under what parameters of plasma and microwave these processes could be effective for transmitting a message written on the signal wave to the vehicle through the plasma sheath.

#### STATUS OF EFFORT

The results of our theoretical research is reported in the publications listed below. We established a scientific contact with Dan Katayama and his co-workers at the Phillips Laboratory, Hanscom AFB, who are considering testing our ideas experimentally in laboratory conditions. As the request of this group, we have found the optimal plasma parameters and electromagnetic wave frequencies to be used in such an experiment with the answers to a number of theoretical questions.

The study of nonlinear plasma processes for communications with reentry vehicles revealed some properties of these processes that appeared to be very promising for solving another important problem, i.e., reduction of drag on a hypersonic airplane.

#### NEW FINDINGS

We showed that the nonlinear plasma processes are effective enough to be used for communications. Brillouin scattering is shown to give much stronger signal than Raman scattering, although it has to compete with a higher noise level resulting from turbulence. Fast electrons generated in the process of the resonant absorption of the signal wave are shown to penetrate plasma as deep as five to ten cm and, therefore, are capable of reaching the vehicle and transmitting information

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written on the signal wave. The best results can be achieved when several communication channels based on these processes are used simultaneously.

#### PERSONNEL SUPPORTED

##### Faculty

A.C. Newell

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##### Post Docs

A. Pouchkarev

S. Nazarenko

##### Graduate Students

N. Komorova

#### PUBLICATIONS

Communication with re-entry space vehicles via short pulses,  
A.C. Newell and S. Nazarenko, AGU Radio Science, vol. 30, ( 6), 1753-1766  
(1995).

Resonant absorption of short pulses, A.C. Newell and A.M. Rubenchik,  
Phys. Lett, 197 (1995) 159-163.

Communication through plasma sheaths via Raman scattering process,  
A.C. Newell and V.E. Zakharov, Physics of Plasmas (formerly Phys. Fluids B) 1  
(1994) 2827-2834.

#### INTERACTIONS/TRANSITION

Collaborative visit at Dayton AFB

#### TRANSITIONS

n/a

#### NEW DISCOVERIES, INVENTIONS, OR PATENT DISCLOSURES

none

#### HONORS/AWARDS

none